Integer-Programming Approach to Group-Merit Selection

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The ultimate goal of artificial selection is to achieve high genetic response in a given trait(s). In real-world populations, the unavoidable effect of selection is the build-up of genetic similarities within and among individuals (reduction of diversity). This in turn limits the attainment of genetic response in later generations. In reality, the approach is to select n individuals out of N candidates, where $n < N$. In order to alleviate the contradictory effects, one may impose certain relationship restrictions to these selections (e.g. maximum tolerable number of half-sibs in the selected set). More efficient approaches have been developed so far. One of them is the group-merit selection, where the goal is to maximize group merit of a selected set, with particular importance assigned to the diversity. The approach to this maximization taken so far consisted of a series of numerical iterations that have been relatively robust in many practical situations. However, as tree breeding approaches to advanced generations and pedigrees become more complex, finding the best set of individuals becomes more challenging. Therefore, we rephrase (without giving the theoretical development) the problem to the integer programming, and show how to search for solutions using commercially available optimization software tools. We focus on demonstration of the tool using small examples, particularly how to identify the best set of n individuals given the pedigree information and breeding values of N candidates. Finally, we discuss the applicability of the proposed approach in solving real-world examples in forest tree breeding programs, and outline the future development.